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Animal Deterrents/Security

C.M. Mike Stine

Tyco Electronics-Energy Division

Sheila Frasier

Southern Engineering

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The vast majority of electrical utility substations designed to transform transmission voltages to distribution class voltages employ an open-air design. The configurations may vary, but usually consist of equipment that utilizes polymer or porcelain insulators or bushings to create electrically insulated creepage and dry arc distances between the potential voltage carried by the bus or conductor and the grounded portions of the equipment or structure. Although these insulators or bushings provide the proper insulation distance for normal operation voltages (AC, DC, and BIL), they do not provide sufficient distances to eliminate bridging of many animals from potential to ground. This animal bridging situation usually exists at the low side or distribution voltage portion of the substation (12 through 36 kV), but depending on the size and type of the animal, can also affect higher voltage equipment. Utilities have reported that animal-caused outages have become a major problem affecting the reliability and continuity of the electrical system and are actively taking steps to prevent it.

The effects of animal bridging ranges from nuisance trips of the electrical system which may be a momentary occurrence, to faults that may interrupt power for long periods of time. Aside from the inconvenience and reliability aspects of animal-induced outages, there can be damage to the substation equipment ranging from porcelain bushings and insulators that may cost as little as \$20.00, to complete destruction of large transformers running into the millions of dollars. There can also be an environmental risk involved with catastrophic failure such as oil spillage from equipment that has ruptured due to electrical faults.

Damage from outages is not limited to the equipment owned by the electrical utility. Many heavy industrial plants such as pulp and paper, petrochemical, and car manufacturers employ processes that are sensitive to interruptions and may result in significant time and money to reestablish production. The proliferation of computers, programmable logic controllers (PLCs), and other electrically sensitive devices in the workplace is also a reliability concern.

In addition to the concern for protecting assets such as substation equipment, improving the reliability of the system, eliminating environmental risks, and ensuring customer satisfaction and loyalty, the conservation of endangered and protected animal species is an issue. It is important to be educated and informed about the species and types of animals that are protected in each individual area or location.

To evaluate the problem and its possible solutions, several aspects need to be investigated:

- Animal type, size, and tendencies
- Equipment voltage rating and clearance from electrical ground
- Natural surroundings
- Method animals enter substation
- Influences attracting the animals
- Barrier methods available to keep the animal out
- Deterrent methods to repel the animals
- Insulation options

10.1 Animal Types

10.1.1 Clearance Requirements

The following table has been developed to aid in establishing minimum phase-to-ground and phase-to-phase clearances for the associated animals. This table is for reference only.

TABLE 10.1 Typical Clearance Requirement by Animal

Animal Type	Phase-to-Phase	Phase-to-Ground
Squirrel	18" (450 mm)	18" (450 mm)
Opossum/Raccoon	30" (750 mm)	30" (750 mm)
Snake	36" (900 mm)	36" (900 mm)
Crow/Grackle	24" (600 mm)	18" (450 mm)
Migratory Large Bird	36" (900 mm)	36" (900 mm)
Frog	18" (450 mm)	18" (450 mm)
Cat	24" (600 mm)	24" (600 mm)

10.1.2 Squirrels

In North America, a common culprit causing bridging is the squirrel. Although there are many varieties of squirrels, it can be assumed that the nominal length of a squirrel is 18" (450 mm). Using this dimension, you can evaluate equipment and clearances to determine areas where bridging could occur between potential and ground or phase-to-phase. Clearances for modern substation equipment rated 35 kV and above will normally be sufficient to eliminate squirrel-caused problems; however, distances between phases and between phase and grounded structures should be examined.

There are several schools of thought regarding the reason squirrels often enter substations. One explanation offered is the proximity of trees and vegetation near the substation site that may attract squirrels. Some utilities report that removal of this vegetation had no effect on the squirrel-caused outages. Experts have theorized that the animals' path is predetermined and the construction of a structure will not deter a squirrel from following his intended route. Others believe that the animals are attracted by heat or vibration emitted from the electrical equipment. Regardless of the reason, squirrels are compelled toward intrusion.

The entry into the substation does not always occur over, under, or through the outer fence of the site. Squirrels are very adept at traveling along overhead conductors and often enter the substation in this manner. Because of this fact, perimeter barriers are often ineffectual in preventing squirrel entry.

10.1.3 Birds

Birds create several problems when entering an electrical substation. The first and most obvious is the bridging between phase-to-ground or phase-to-phase caused by the wingspan when flying into or exiting the structure. Another problem is the bridging caused by debris used to build nests. Many times material

such as strands of conductors or magnetic recording tape may be readily available from the surrounding area and be utilized by the birds. This conductive debris is often dragged across the conductor/busbar and results in flashovers, trips, or faults. The third problem is contamination of insulators caused by regurgitation or defecation of the birds. When this residue is allowed to remain, it can result in flashovers from potential to ground across the surface of the porcelain or polymer insulator by essentially decreasing the insulated creepage distance. The fourth possibility is commonly known as a “streamer outage.” Streamers are formed when a bird defecates upon exiting a nest that has been built above an insulator. The streamers may create a path between the structure and conductor/bus, resulting in a flashover. Birds will tend to make nests in substations in an effort to eliminate possible predators from attacking the nest for food. The construction of nests in substations can, in turn, attract other animals such as snakes, cats, and raccoons into the area searching for food.

10.1.4 Snakes

Snakes are a major contributor to substation outages. In some areas, snakes are responsible for virtually all substation wildlife outages. Because of their size and climbing ability, snakes can reach most parts of a substation without difficulty. Snake-proofing substations can sometimes create problems rather than solving them. Snakes typically enter substations hunting birds and eggs. Eliminating these predators can lead to an increase in the bird population inside the substation boundaries. This bird infestation can then lead to bird-induced problems unless additional measures are taken.

10.1.5 Raccoons

Raccoons are excellent climbers and can easily gain access to substations. Unlike snakes, raccoons will occasionally enter substations for no particular reason except curiosity. Because of their large size, raccoons can easily bridge phase-to-phase and phase-to-ground distances on equipment with voltage ratings up to 25 kV.

10.2 Mitigation Methods

10.2.1 Barriers

Some of the barrier methods available include cyclone fences, small mesh wire fences, smooth climbing guards, electric fences, solid wall barriers, and fences with unconventional geometries. Barrier methods can be very effective against certain animals. Some utilities report that the use of small mesh fencing along the lower 3–4 feet (1–1.3 meters) of the perimeter has prevented intrusion of certain types of snakes. Several substation owners have incorporated the use of a bare wire attached to a PVC pipe energized with a low voltage transformer creating an electric fence that surrounds the structure inside of the normal property fence. This method has also been proven effective for snakes. Although these barrier designs prevent snakes from entering substations, they do little or nothing to eliminate legged animal intrusions. Smooth climbing guards are also used on structures to prevent some animals from scaling the vertical framework. While these guards work for some legged animals such as dogs and foxes, more agile animals such as squirrels, opossums, and cats can easily circumnavigate the devices.

10.2.2 Deterrents

There are a myriad of commercially available deterrent devices on the market. Many of the devices have actually come from applications in the household market to repel pests such as squirrels and pigeons from property. Although numerous, most devices have a limited effect on wildlife. Some of these include ultrasonic devices, devices producing loud noises at intermittent periods, chemical repellents, sticky gels, predator urine, plastic owls or snakes, poisons, and spined perching deterrents for birds. Ultrasonic devices tend to have an initial impact on animals, but have reportedly become ineffective after a relatively

short period of time either due to the animal adapting to the sounds or the need to maintain the devices. Loud noise devices, like ultrasonics, soon lose the ability to repel the animals as they become familiar with the sound and lack of consequence. Chemical repellents, sticky gels, and predator urine have been shown effective against some animals when reapplied at frequent intervals. Poisons have been used to curb infestations of pests such as pigeons, but will sometimes result in collateral effects on pets and other animals if the pest is allowed to die outside of the substation boundaries. Spined perching deterrents have proven very successful in preventing smaller birds from building nests or congregating above electrically sensitive areas, but can sometimes serve as a functional anchor for greater sized birds to secure large nests.

10.2.3 Insulation

Insulating live conductors and hardware can be very effective in eliminating animal outages. Insulation systems are available in several forms:

- Spray-on RTV coatings
- Insulating tapes
- Heat-shrinkable tubings, tapes, and sheet materials
- Pre-formed insulating covers

Insulation systems should be used at locations where animals can possibly make contact phase-to-ground or phase-to-phase. Typical applications include:

- Equipment bushing hardware (i.e., circuit breakers, reclosers, transformers, potential transformer, capacitors, regulators, etc.)
- Bus support insulator connections to structure or bus
- Hook switch insulator connections to switch base or bus
- Any area where clearance between bus and grounded equipment or structure is insufficient to eliminate bridging
- Busbar and conductors where phase-to-phase spacing is inadequate

Because these products are used as insulation on bus, conductor, or hardware, it is critical that they be of a material that is designed for the rigors of the high voltage environment. Unlike barriers and deterrents, the insulating materials are subjected to the electric field and are sometimes applied to the leakage path of other insulating materials such as porcelain. Care should be taken to select products that will withstand the outdoor environment as well as the electrical stress to which they may be subjected.

10.2.4 Isolation Devices

Isolation devices are rigid insulating discs that are installed in the leakage path of porcelain insulators. These devices force animals to climb onto them, isolating them from the ground. These discs are used on both support insulators as well as switch insulators. As with insulating covers, the insulating material must be designed for the outdoor high voltage environment.